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Iikura et al.

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(54) **CONTACT MEMBER, IMAGE CARRIER, AND IMAGE FORMING APPARATUS**

(71) Applicant: **FUJI XEROX CO., LTD.**, Tokyo (JP)

(72) Inventors: **Kazuaki Iikura**, Kanagawa (JP); **Hiroshi No**, Kanagawa (JP); **Koji Tadokoro**, Kanagawa (JP); **Shinya Makiura**, Kanagawa (JP)

(73) Assignee: **FUJI XEROX CO., LTD.**, Tokyo (JP)

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May 29, 2014 (JP) 2014-111293

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G03G 15/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/751*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/75
See application file for complete search history.

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Primary Examiner — David Gray
Assistant Examiner — Sevan A Aydin
(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**

A contact member is fitted in a cylindrical body that is substantially cylindrical and configurates an image carrier, and is supported by the cylindrical body while being in contact with an inner peripheral surface of the cylindrical body at contact portions provided in three areas in a circumferential direction of the cylindrical body. All angles formed by two of straight lines passing through the contact portions and an axial center of the cylindrical body are more than about 90 degrees in a state in which the contact member is supported within the cylindrical body, when viewed from an axial direction of the cylindrical body.

8 Claims, 13 Drawing Sheets

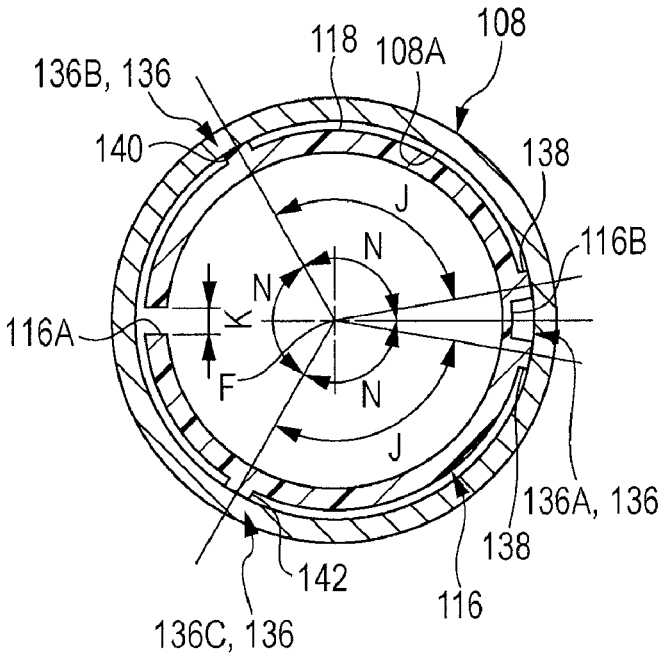


FIG. 1A

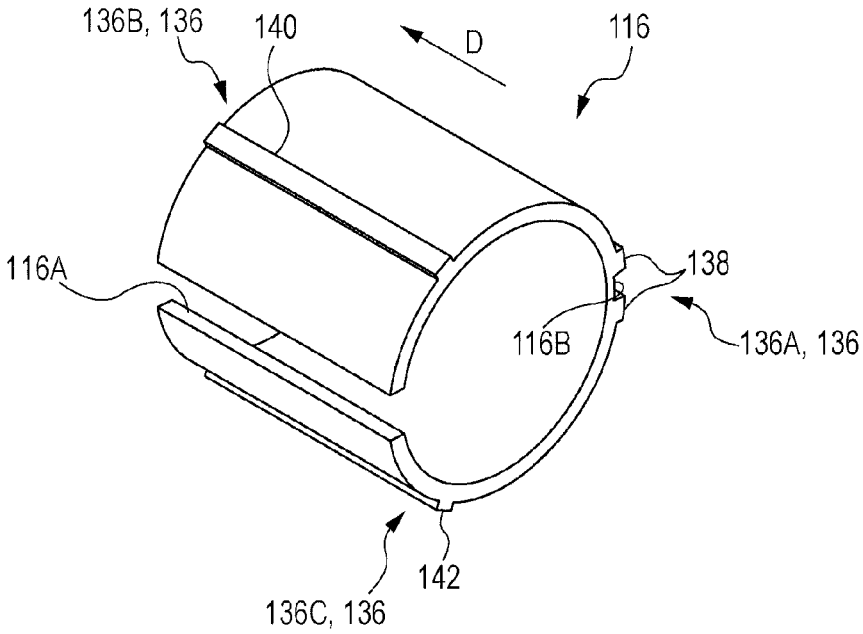


FIG. 1B

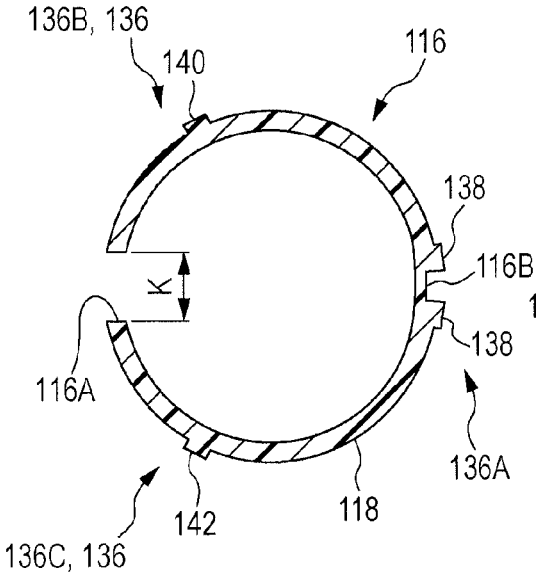


FIG. 1C

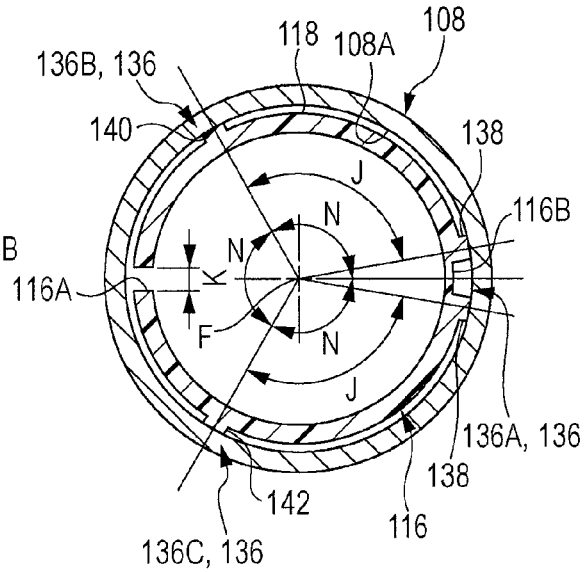


FIG. 2

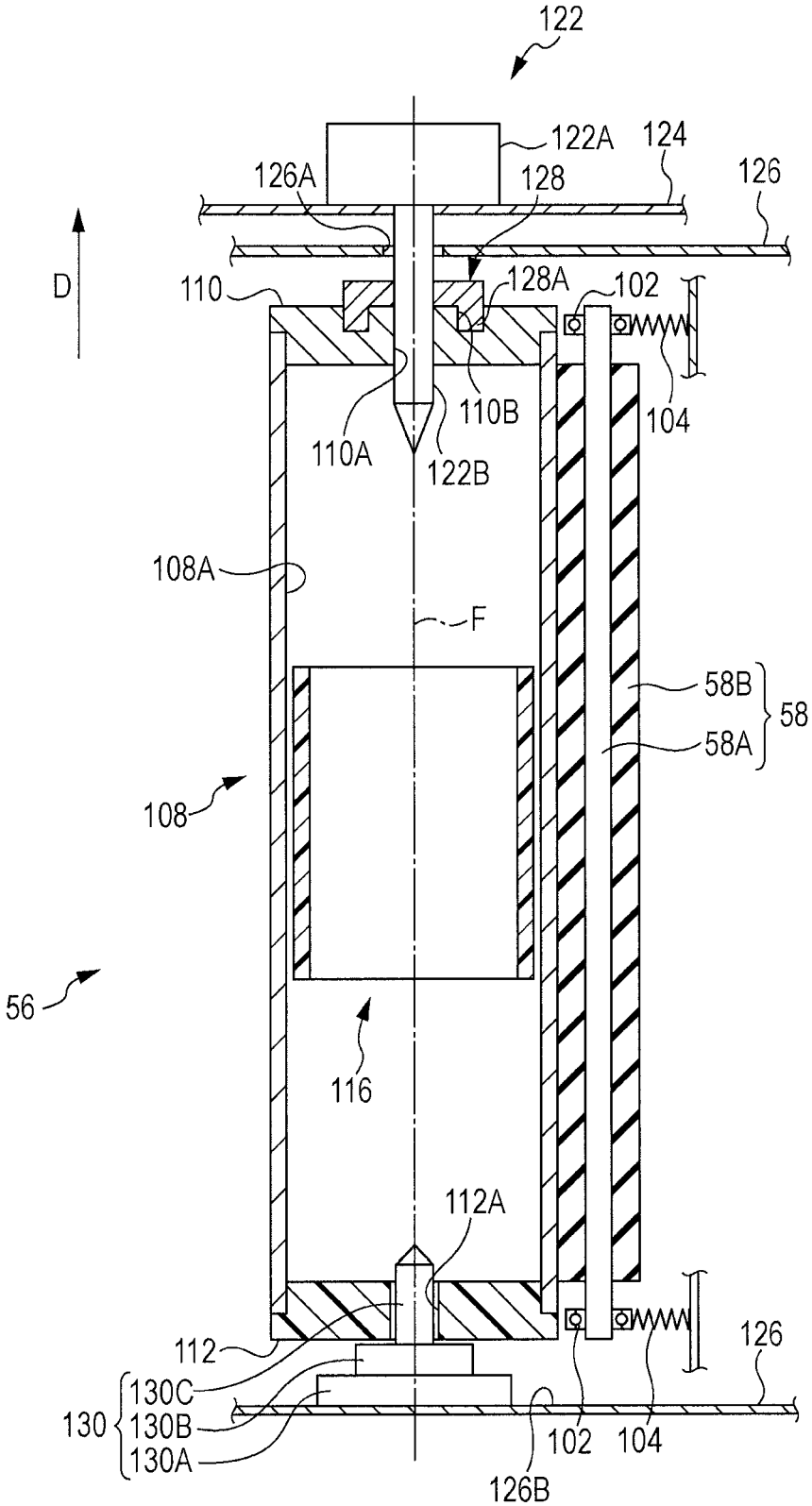

122
122A
124
126A
128
126
D
110
128A
102
110B
104
110A
122B
108A
F
58B
58
58A
108
56
116
112A
112
126
130C
130
130B
130A
102
104
126B

FIG. 3

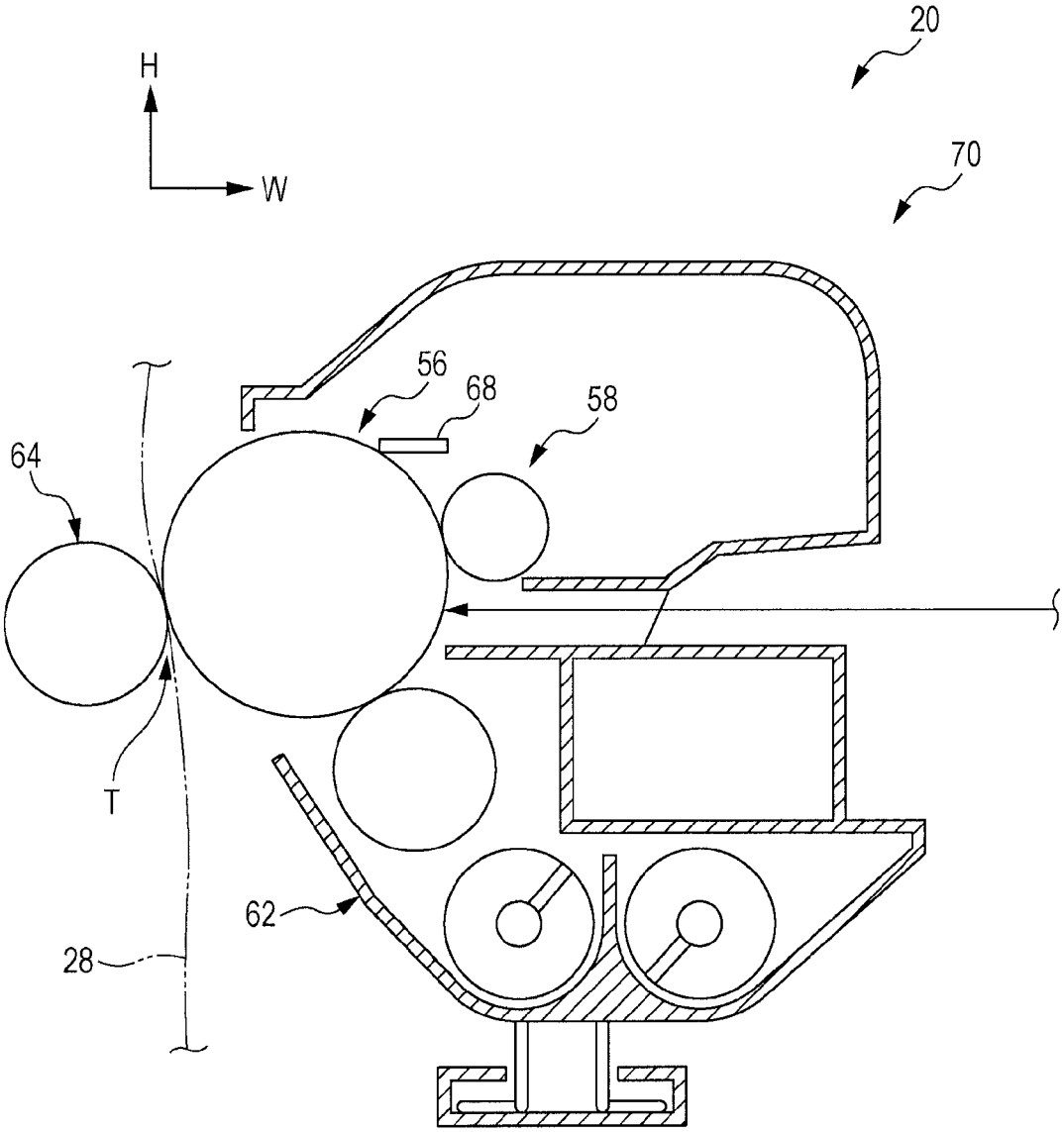


FIG. 4

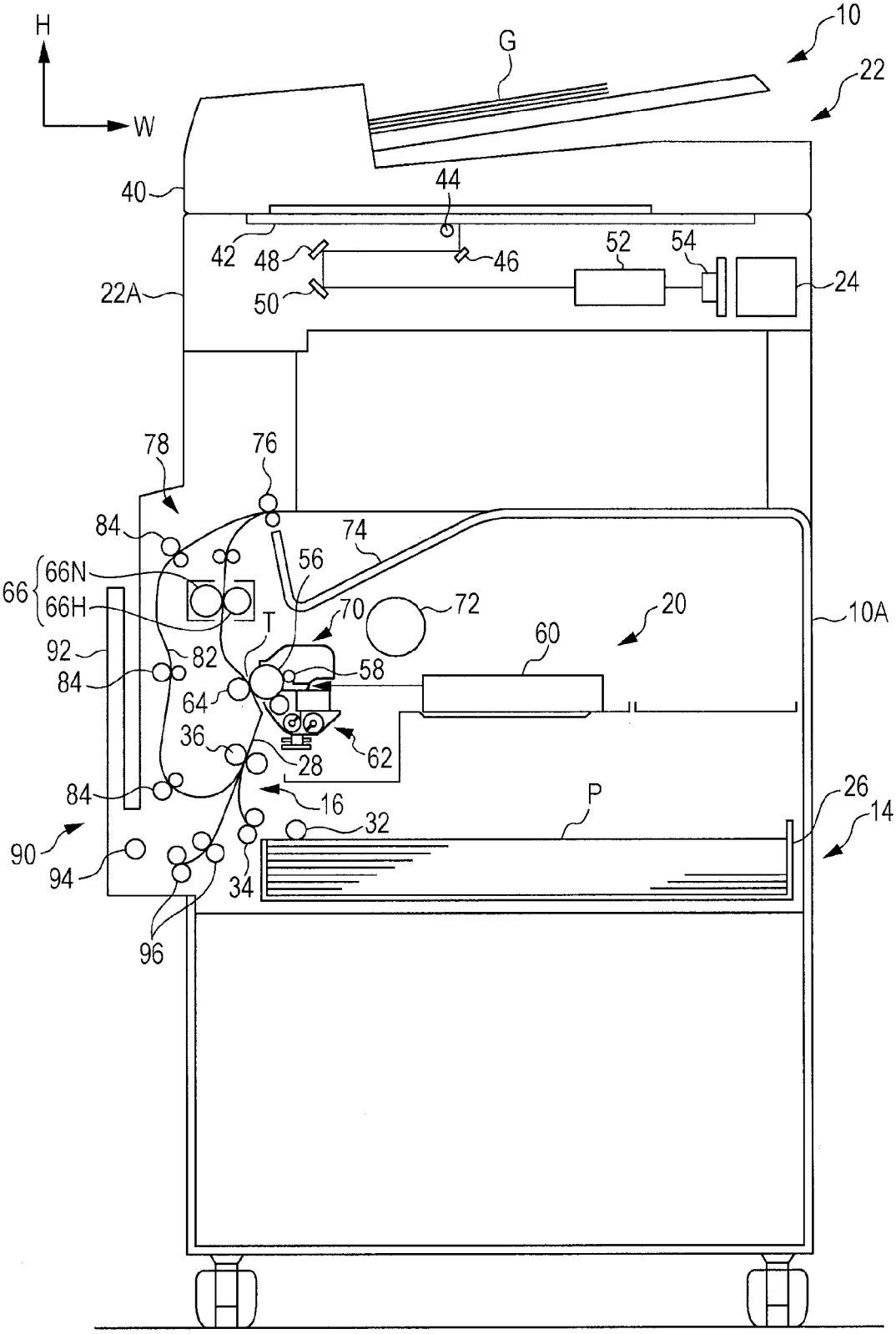

H
W
G
10
22
40
44
42
48
46
52
54
24
22A
50
78
76
84
74
56
66
66N
66H
T
70
72
20
10A
92
82
60
84
58
64
36
62
28
84
16
26
P
14
32
90
94
34
96

FIG. 5A

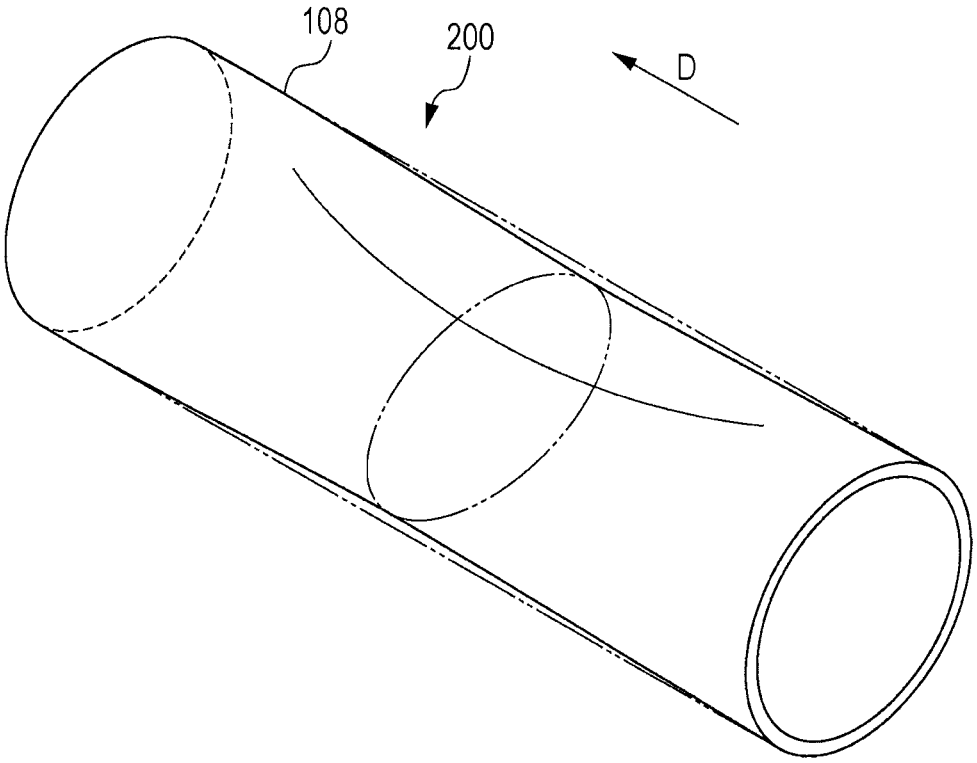


FIG. 5B

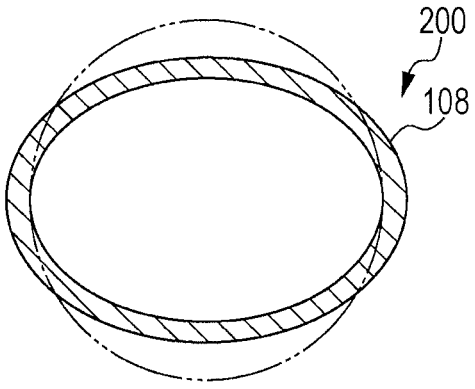


FIG. 6A

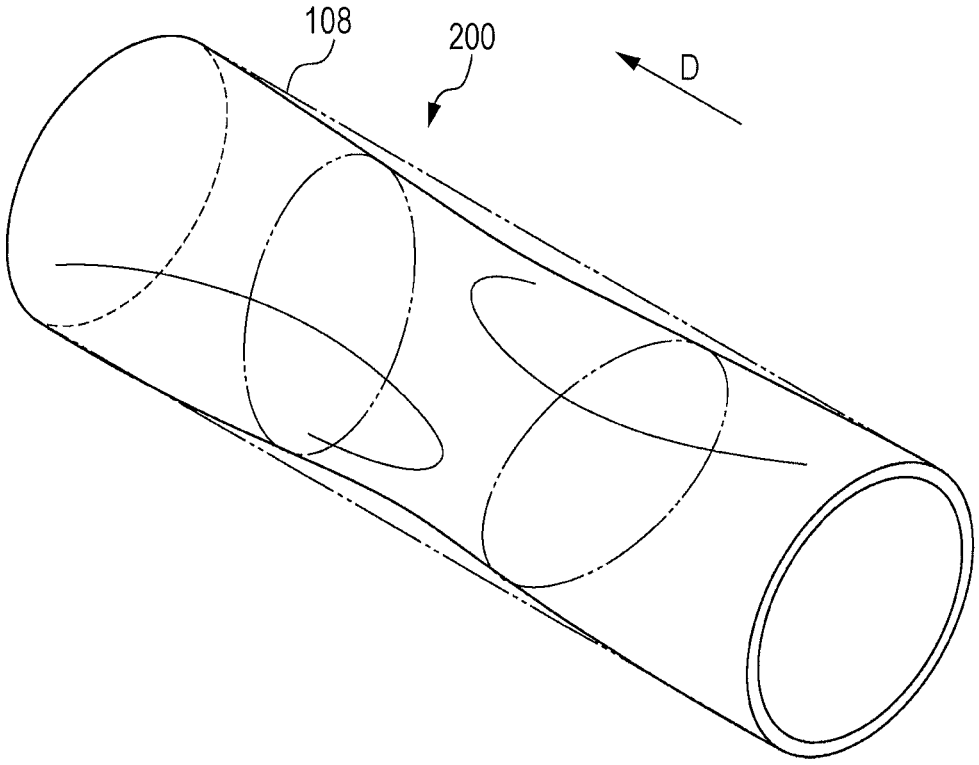


FIG. 6B

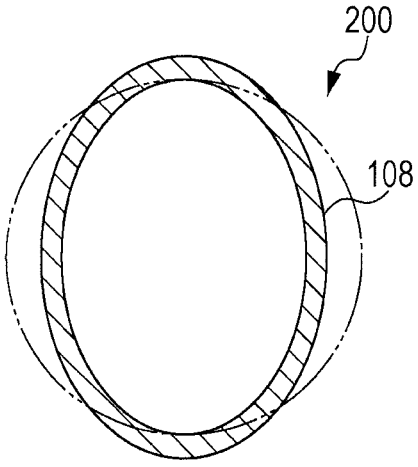


FIG. 6C

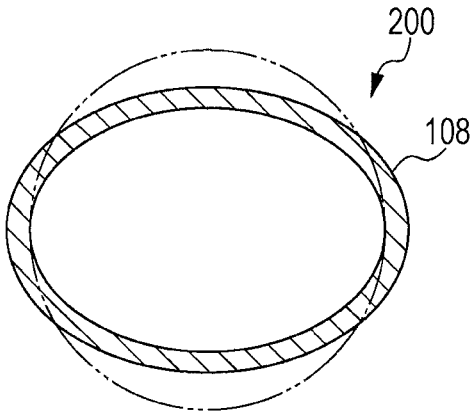


FIG. 7B

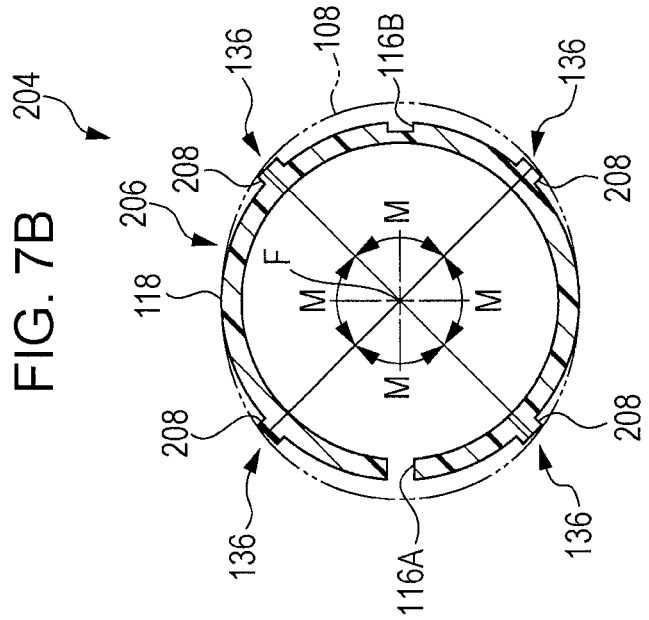
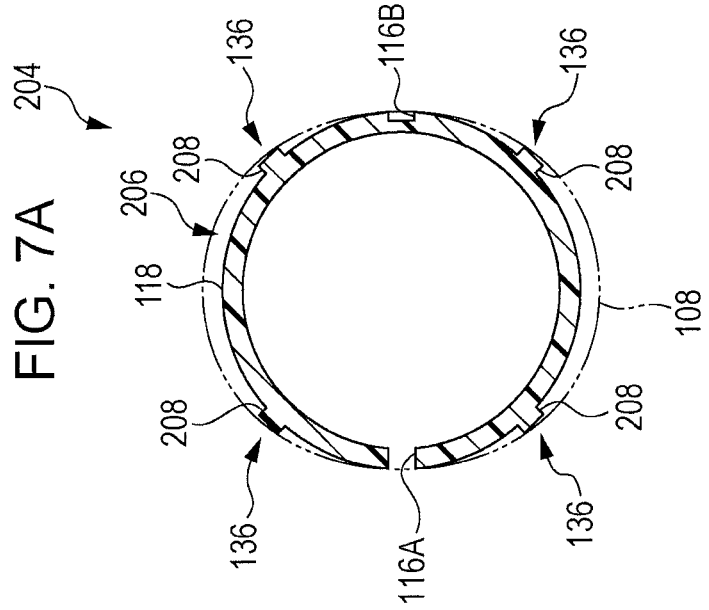

204
136
108
116B
136
208
206
208
118
F
M
M
M
M
208
208
136
136
116A

FIG. 7A


204
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116B
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FIG. 8A

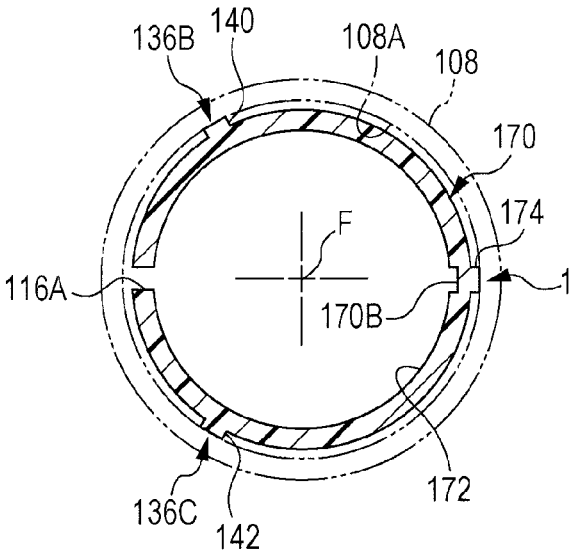


FIG. 8B

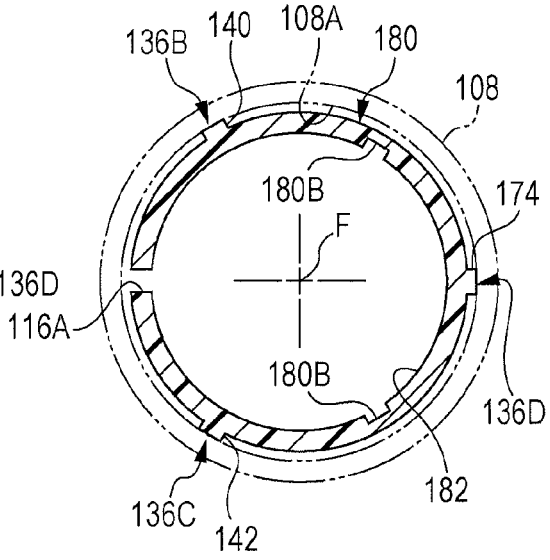


FIG. 8C

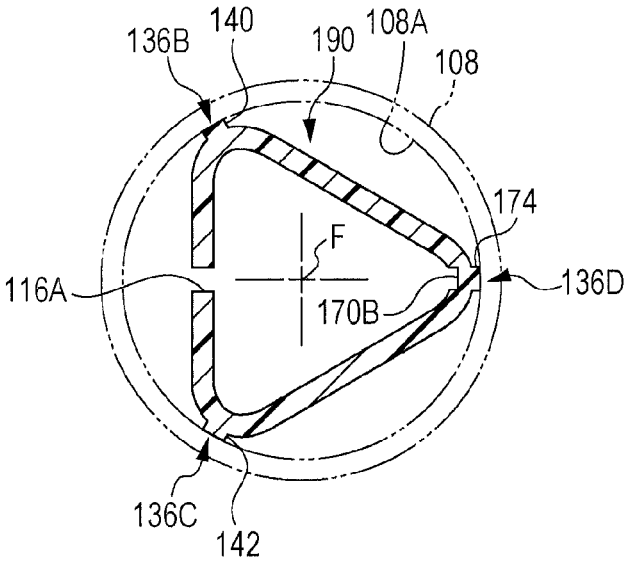
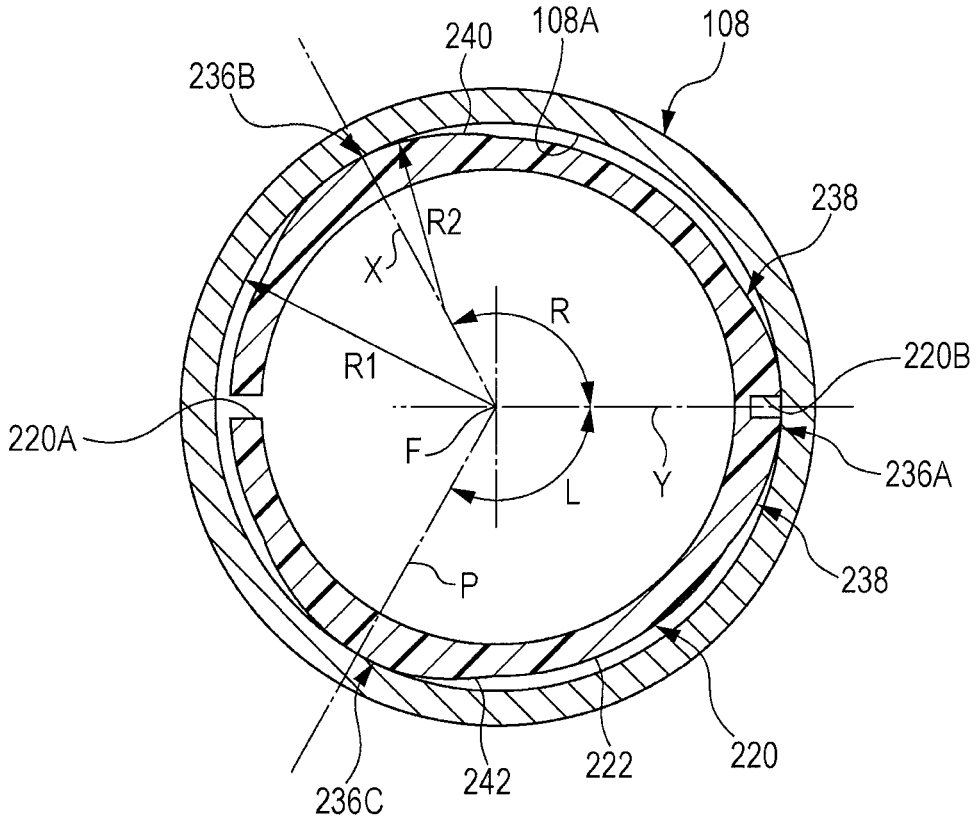


FIG. 9A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108A
108
236B
238
R2
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R
R1
220B
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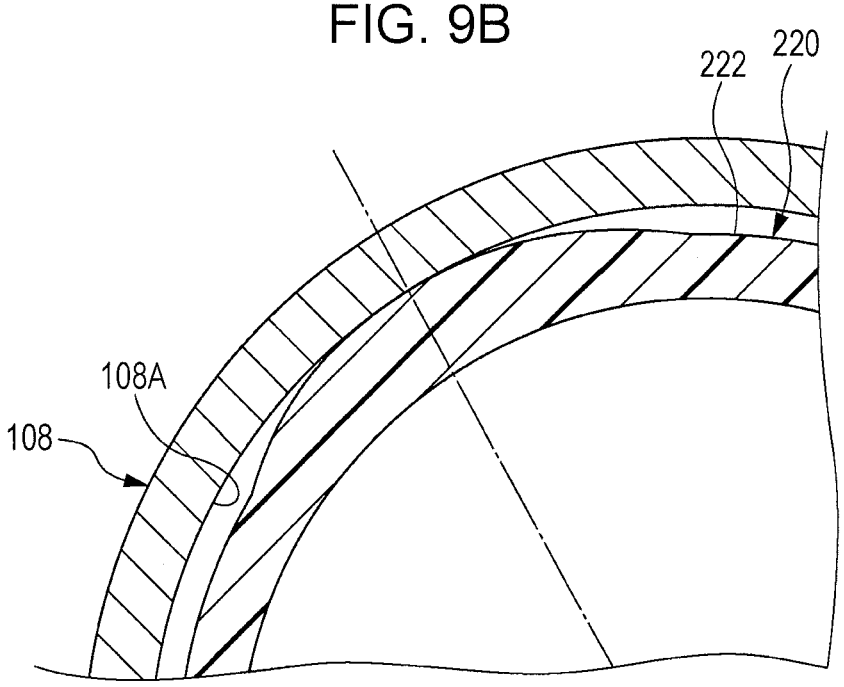
F
236A
L
Y
238
P
236C
242
222
220

FIG. 9B


222
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108A
108

FIG. 10

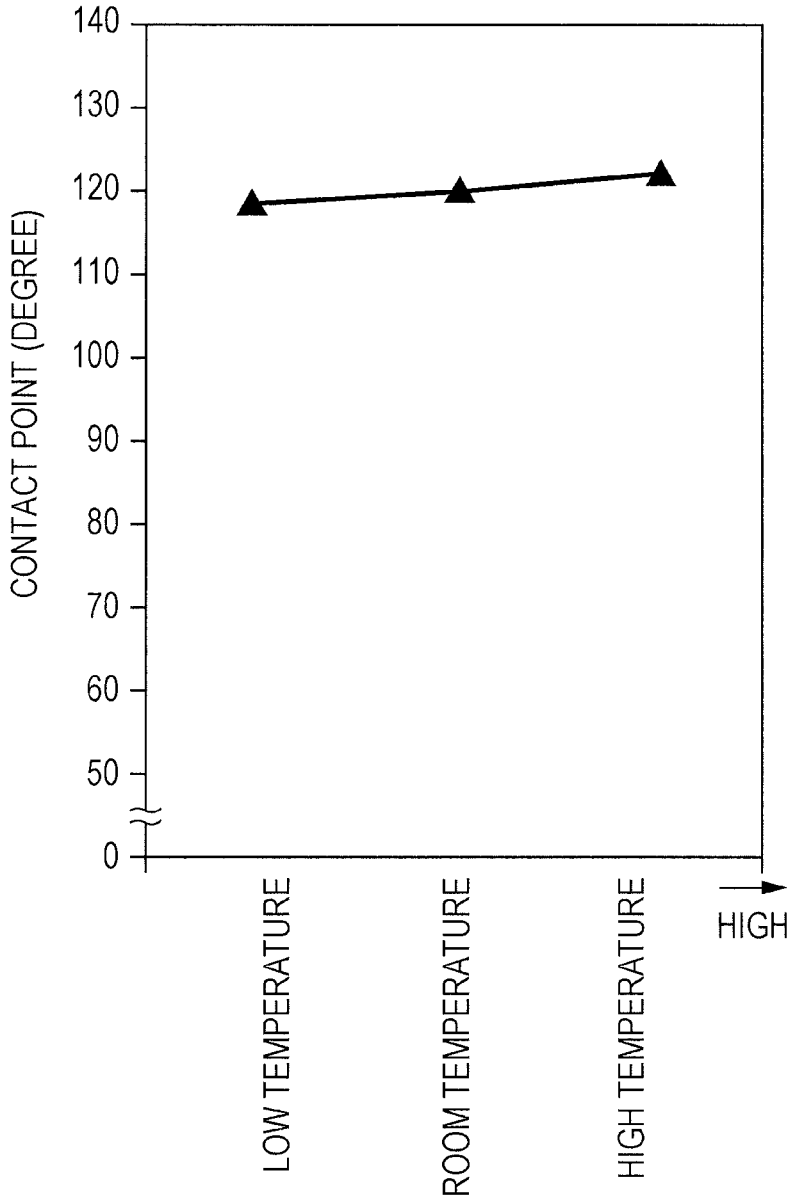

140
130
120
110
100
90
80
70
60
50
0
CONTACT POINT (DEGREE)
LOW TEMPERATURE
ROOM TEMPERATURE
HIGH TEMPERATURE
HIGH

FIG. 11A

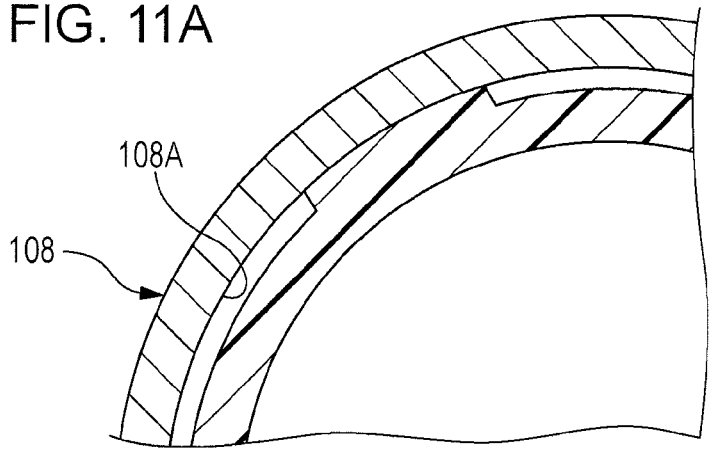


FIG. 11B

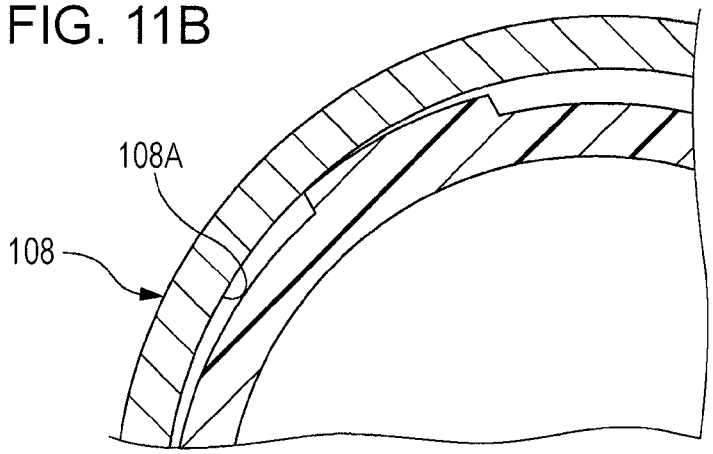


FIG. 11C

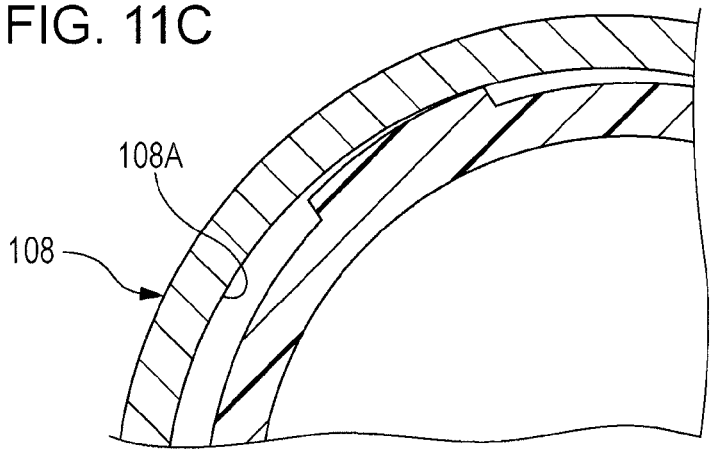
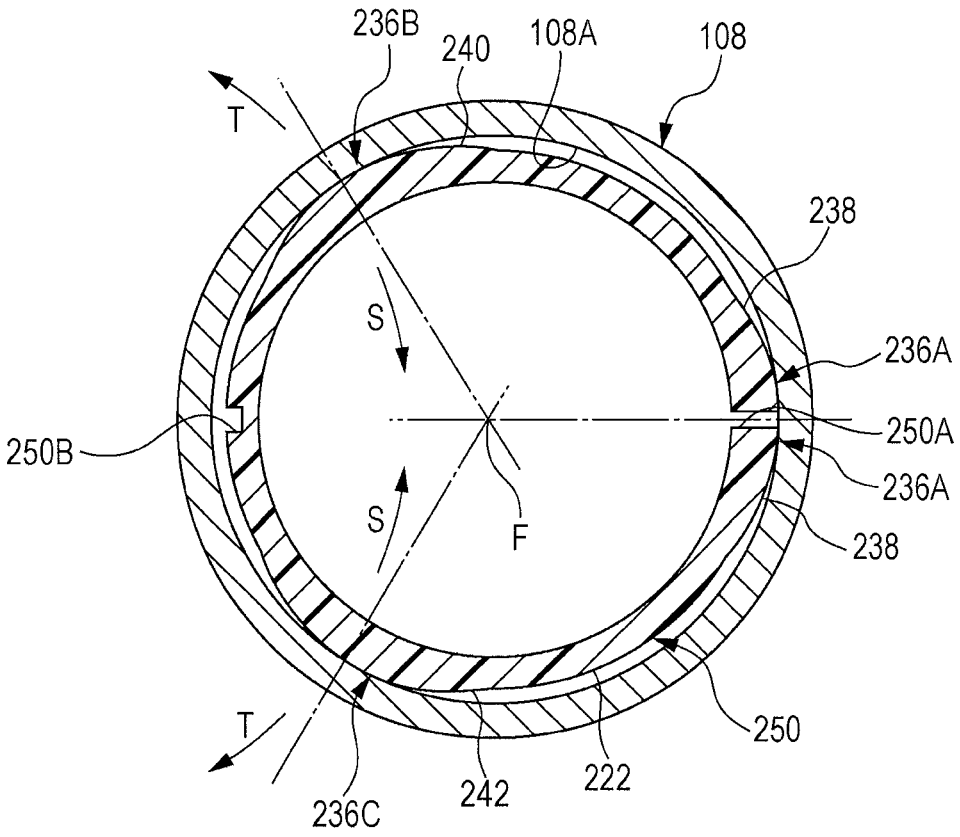


FIG. 12


236B
240
108A
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236A
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250A
236A
S
F
238
T
250
236C
242
222

FIG. 13A

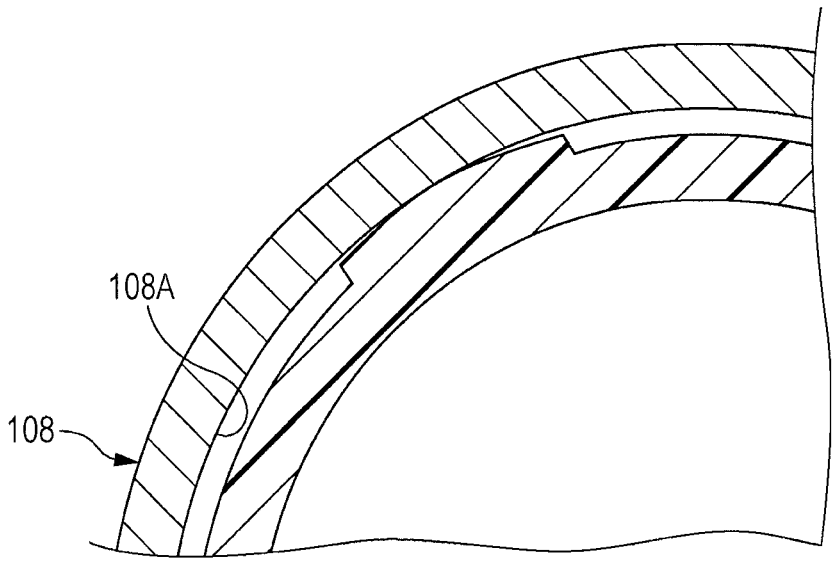
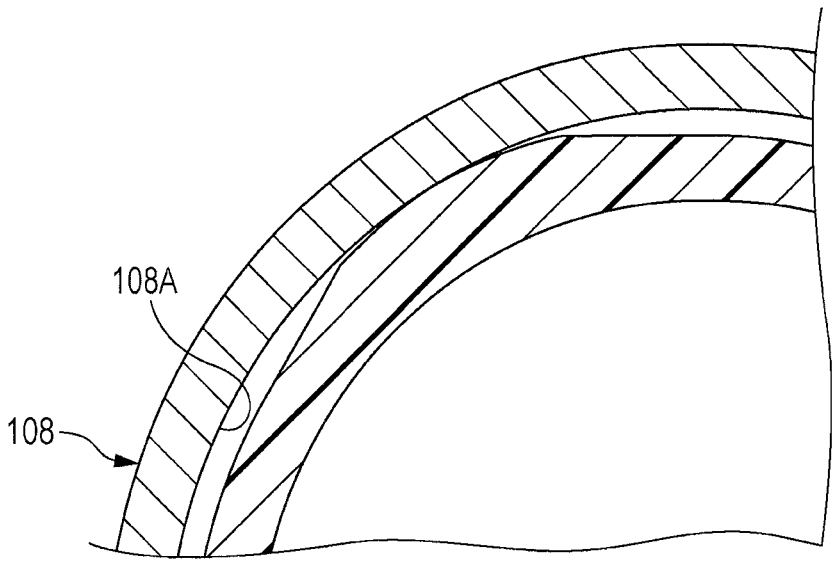


FIG. 13B



CONTACT MEMBER, IMAGE CARRIER, AND IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority under 35 USC 119 from Japanese Patent Applications No. 2013-192157 filed Sep. 17, 2013 and No. 2014-111293 filed May 29, 2014.

BACKGROUND

1. Technical Field

The present invention relates to a contact member, an image carrier, and an image forming apparatus.

2. Summary

According to an aspect of the invention, there is provided a contact member fitted in a cylindrical body that is substantially cylindrical and configurates an image carrier, and supported by the cylindrical body while being in contact with an inner peripheral surface of the cylindrical body at contact portions provided in three areas in a circumferential direction of the cylindrical body. All angles formed by two of straight lines passing through the contact portions and an axial center of the cylindrical body are more than about 90 degrees in a state in which the contact member is supported within the cylindrical body, when viewed from an axial direction of the cylindrical body.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

FIGS. **1**A, **1**B, and **1**C are a perspective view, a cross-sectional view, and a cross-sectional view, respectively, of a contact member according to a first exemplary embodiment of the present invention;

FIG. **2** is a cross-sectional view of an image carrier and so on according to the first exemplary embodiment;

FIG. **3** is a schematic structural view of an image forming unit used in an image forming apparatus according to the first exemplary embodiment;

FIG. **4** is a schematic structural view of the image forming apparatus according to the first exemplary embodiment;

FIGS. **5**A and **5**B are a perspective view and a cross-sectional view, respectively, illustrating a deformed state of an image carrier according to a first comparative example in contrast to the image carrier of the first exemplary embodiment;

FIGS. **6**A, **6**B, and **6**C are a perspective view, a cross-sectional view, and a cross-sectional view, respectively, illustrating the deformed state of the image carrier according to the first comparative example in contrast to the image carrier of the first exemplary embodiment;

FIGS. **7**A and **7**B are cross-sectional views of an image carrier according to a second comparative example in contrast to the image carrier of the first exemplary embodiment;

FIGS. **8**A, **8**B, and **8**C are cross-sectional views of contact members according to second, third, and fourth exemplary embodiments of the present invention, respectively;

FIGS. **9**A and **9**B are a cross-sectional view and an enlarged sectional view, respectively, of a contact member according to a fifth exemplary embodiment of the present invention;

FIG. **10** shows evaluation results of the contact member of the fifth exemplary embodiment;

FIGS. **11**A, **11**B, and **11**C are cross-sectional views of a contact member according to a comparative example in contrast to the contact member of the fifth exemplary embodiment;

FIG. **12** is a cross-sectional view of a contact member according to a sixth exemplary embodiment of the present invention; and

FIGS. **13**A and **13**B are enlarged views of modifications of the contact members of the fifth and sixth exemplary embodiments, respectively.

DETAILED DESCRIPTION

First Exemplary Embodiment

A contact member, an image carrier, and an image forming apparatus according to a first exemplary embodiment of the present invention will be described with reference to FIGS. **1**A, **1**B, and **1**C to FIGS. **7**A and **7**B. In the figures, arrow H shows an apparatus up-down direction (vertical direction), arrow W shows an apparatus width direction (horizontal direction), and arrow D shows an apparatus depth direction (horizontal direction).

Overall Configuration

As illustrated in FIG. **4**, in an image forming apparatus **10** according to the first exemplary embodiment, a storage section **14**, a transport section **16**, an image forming section **20**, and a document reading section **22** are provided in this order from a lower side toward an upper side in the apparatus up-down direction (direction of arrow H). The storage section **14** stores sheet members P serving as recording media. The transport section **16** transports the sheet members P stored in the storage section **14**. The image forming section **20** forms images on the sheet members P transported from the storage section **14** by the transport section **16**. The document reading section **22** reads a read document G. The image forming apparatus **10** further includes a manual paper feed section **90** from which a sheet member P is supplied manually.

Storage Section

The storage section **14** includes a storage member **26** that can be drawn out from an apparatus body **10**A of the image forming apparatus **10** toward a front side in the apparatus depth direction. In the storage member **26**, sheet members P are stacked. The storage section **14** further includes a feed roller **32** that feeds out the stacked sheet members P to a transport path **28** that configurates the transport section **16**.

Transport Section

The transport section **16** includes separation rollers **34** disposed on a downstream side of the feed roller **32** in a transport direction of sheet members P (hereinafter simply referred to as a "transport-direction downstream side") to separate and transport the sheet members P one by one.

On the transport-direction downstream side of the separation rollers **34** in the transport path **28**, registration rollers **36** are disposed to temporarily stop a sheet member P and to feed out the sheet member P to a transfer position T (to be described later) at a predetermined timing.

At a terminal end of the transport path **28**, output rollers **76** are disposed to output a sheet member P, on which an image is formed by the image forming section **20**, into an output portion **74** provided in an upper part of the image forming section **20**.

To form images on both sides of a sheet member P, a double-side transport unit **78** for inverting the sheet member P is provided in a side part of the apparatus body **10**A. The double-side transport unit **78** includes a reverse path **82** into which a sheet member P is transported by reversing the output

rollers **76**. Further, plural transport rollers **84** are disposed along the reverse path **82**. The sheet member P sent by the transport rollers **84** is transported to the registration rollers **36** again in an inverted state.

Manual Paper Feed Section

Next to the double-side transport unit **78**, the folding manual paper feed section **90** is provided. The manual paper feed section **90** includes an openable manual paper feed member **92**. The manual paper feed section **90** further includes a paper feed roller **94** and plural transport rollers **96** that transport a sheet member P fed from the open manual paper feed member **92**. The sheet member P transported by the transport rollers **96** is transported to the registration rollers **36**.

Document Reading Section

The document reading section **22** provided in the upper part of the image forming apparatus **10** includes a light source **44** that radiates light onto a read document G transported by an automatic document transport device **40** for transporting the read document G or a read document G placed on a platen glass **42**.

The document reading section **22** further includes an optical system configurated by a full-rate mirror **46**, a half-rate mirror **48**, a half-rate mirror **50**, and an imaging lens **52**. Light radiated from the light source **44** is reflected by a read document G, and the reflected light is reflected by the full-rate mirror **46** in a direction parallel to the platen glass **42**. The half-rate mirror **48** reflects the reflected light from the full-rate mirror **46** in a downward direction. The half-rate mirror **50** reflects and folds back the reflected light from the half-rate mirror **48** in the direction parallel to the platen glass **42**. The reflected light folded back by the half-rate mirror **50** enters the imaging lens **52**.

The document reading section **22** further includes a photoelectric conversion element **54** that converts the reflected light imaged by the imaging lens **52** into electric signals, and an image processing unit **24** that subjects the electric signals converted by the photoelectric conversion element **54** to image processing.

The light source **44**, the full-rate mirror **46**, the half-rate mirror **48**, and the half-rate mirror **50** are movable along the platen glass **42**. To read a read document G placed on the platen glass **42**, the light source radiates light onto the read document G while moving the light source **44**, the full-rate mirror **46**, the half-rate mirror **48**, and the half-rate mirror **50**. Reflected light from the read document G is imaged on the photoelectric conversion element **54**.

To read a read document G transported by the automatic document transport device **40**, the light source **44**, the full-rate mirror **46**, the half-rate mirror **48**, and the half-rate mirror **50** are stopped. The light source **44** radiates light onto the read document G, and reflected light from the read document G is imaged on the photoelectric conversion element **54**.

Image Forming Section

As illustrated in FIG. **3**, the image forming section **20** includes an image carrier **56**, a charging roller **58**, an exposure device **60** (see FIG. **4**), and a developing device **62**. The charging roller **58** charges a surface of the image carrier **56**. The exposure device **60** forms an electrostatic latent image by radiating exposure light onto the surface of the image carrier **56** charged according to image data. The developing device **62** develops the electrostatic latent image into a visible toner image.

The image forming section **20** further includes a transfer roller **64**, a fixing device **66** (see FIG. **4**), and a cleaning blade **68**. The transfer roller **64** transfers a toner image formed on the surface of the image carrier **56** onto a sheet member P transported along the transport path **28**. The fixing device **66** is composed of a heating roller **66**H and a pressurizing roller **66**N, and fixes the toner image on the sheet member P with heat and pressure. The cleaning blade **68** cleans the image carrier **56** by scraping residual toner off the image carrier **56** after the toner image is transferred.

As illustrated in FIG. **4**, a toner cartridge **72** connected to the developing device **62** by an unillustrated supply pipe is disposed on an obliquely upper side of the exposure device **60**. The toner cartridge **72** is filled with toner to be supplied to the developing device **62** through the supply pipe.

In this configuration, when a sheet member P is fed out from the registration rollers **36**, it is transported to the transfer position T defined by the image carrier **56** and the transfer roller **64** and is transported while being nipped between the image carrier **56** and the transfer roller **64**. Thus, a toner image formed on the image carrier **56** is transferred onto the sheet member P.

Here, the image carrier **56**, the charging roller **58**, the developing device **62**, and the cleaning blade **68** configurate an image forming unit **70**. The image forming unit **70** is removably mounted the apparatus body **10**A.

The image carrier **56**, the charging roller **58**, and so on will be described in detail later.

Operation of Overall Configuration

In the image forming apparatus **10**, an image is formed in the following procedure.

First, the charging roller **58** to which voltage is applied uniformly and negatively charges the surface of the image carrier **56** with a predetermined potential. Next, the exposure device **60** forms an electrostatic latent image by radiating exposure light onto the charged surface of the image carrier **56** on the basis of image data read by the document reading section **22** or externally input data.

The electrostatic latent image corresponding to the image data is thereby formed on the surface of the image carrier **56**. This electrostatic latent image is developed into a visible toner image by the developing device **62**.

A sheet member P is fed out from the storage member **26** into the transport path **28** by the feed roller **32** or is fed from the manual paper feed member **92** into the transport path **28** by the paper feed roller **94**, and is sent to the transfer position T by the registration rollers **36** at a predetermined timing. At the transfer position T, the sheet member P is transported while being nipped between the image carrier **56** and the transfer roller **64**, and the toner image formed on the surface of the image carrier **56** is thereby transferred onto a front surface of the sheet member P.

The transferred toner image is fixed on the sheet member P by passing between the heating roller **66**H and the pressurizing roller **66**N provided in the fixing device **66**. Then, after the toner image is fixed on the front surface of the sheet member P, the sheet member P is output to the output portion **74** by the output rollers **76**.

To also form an image on a back surface of the sheet member P, the sheet member P having the toner image on its surface is not output to the output portion **74**, but is sent to the reverse path **82** by reversing the output rollers **76**. Thus, the sheet member P is inverted, and the transport rollers **84** transport the sheet member P to the registration rollers **36** again.

This time, a toner image is transferred onto the back surface of the sheet member P at the transfer position T, and the sheet member P is then output to the output portion **74** in the above-described procedure.

Structure of Principal Part

Next, the image carrier **56**, the charging roller **58**, and so on will be described.

Charging Roller

As illustrated in FIG. **2**, the charging roller **58** includes a shaft portion **58**A extending in the apparatus depth direction and made of a metal material (for example, stainless steel), and a cylindrical roller portion **58**B made of a rubber material and formed in a shape of a cylinder in which the shaft portion **58**A extends.

Both ends of the shaft portion **58**A are exposed outside from the roller portion **58**B, and are rotatably supported by a pair of bearing members **102**. Biasing members **104** for biasing the bearing members **102** toward the image carrier **56** are disposed on a side of the shaft portion **58**A opposite from the image carrier **56**. With this structure, the roller portion **58**B of the charging roller **58** is pressed against the image carrier **56**. When the image carrier **56** rotates, the charging roller **58** is rotated along with the rotation.

To the shaft portion **58**A, a superposed voltage obtained by superimposing an alternating-current voltage to a direct-current voltage is applied from an unillustrated power supply.

Image Carrier

As illustrated in FIG. **2**, the image carrier **56** includes a cylindrical body **108**, a transmission member **110**, and a support member **112**. The cylindrical body **108** extends in the apparatus depth direction and is cylindrical or substantially cylindrical. The transmission member **110** is fixed to one end (upper side in the figure) of the cylindrical body **108** in the apparatus depth direction (direction similar to an axial direction of the cylindrical body **108** in the first exemplary embodiment). The support member **112** is fixed to the other end (lower side in the figure) of the cylindrical body **108** in the apparatus depth direction. The image carrier **56** further includes a contact member **116** disposed within the cylindrical body **108** to suppress deformation of a cross section of the cylindrical body **108**.

The cylindrical body **108** is obtained by forming a photosensitive layer on an outer surface of a cylindrical base member made of a metal material (for example, aluminum).

The transmission member **110** is made of a resin material and formed in a disc shape. The transmission member **110** is fixed to the one end of the cylindrical body **108** with a part thereof being fitted in the cylindrical body **108**, and closes the open one end of the cylindrical body **108**. The transmission member **110** has a columnar through hole **110**A on an axial center F of the cylindrical body **108**. In an outer surface of the transmission member **110** facing outward in the apparatus depth direction, plural (two in FIG. **2**) recesses **110**B are provided such that the through hole **110**A is located therebetween.

The support member **112** is made of a resin material and formed in a disc shape. The support member **112** is fixed to the other end of the cylindrical body **108** with a part thereof being fitted in the cylindrical body **108**, and closes the other open end of the cylindrical body **108**. The support member **112** has a columnar through hole **112**A on the axial center F of the cylindrical body **108**.

As illustrated in FIG. **2**, the contact member **116** is fitted in the cylindrical body **108**, and is located in the center of the cylindrical body **108** in the apparatus depth direction. As illustrated in FIG. **1**C, the contact member **116** is supported by the cylindrical body **108** while being in contact with an inner peripheral surface **108**A of the cylindrical body **108**.

Specifically, the contact member **116** is made of a resin material (for example, ABS (acrylonitrile-butadiene-styrene) resin), and is cylindrical or substantially cylindrical (C-shaped) to extend in the apparatus depth direction. The contact member **116** has a separate portion **116**A in a circumferential part thereof, as illustrated in FIGS. **1**A and **1**B. Further, as illustrated in FIG. **1**C, a groove portion **116**B extending in the apparatus depth direction is provided on a portion of an outer peripheral surface **118** of the contact member **116** on a side of the axial center F opposite from the separate portion **116**A in a state in which the contact member **116** is disposed within the cylindrical body **108**.

As illustrated in FIG. **1**C, the outer peripheral surface **118** of the contact member **116** has contact portions **136** in contact with an inner peripheral surface **108**A of the cylindrical body **108**. The contact portions **136** extend in the apparatus depth direction, and project in the radial direction. The contact portions **136** are provided in three areas (three positions) on the outer peripheral surface **118**. More specifically, when viewed from the apparatus depth direction, the outer peripheral surface **118** has a contact portion **136**A composed of a pair of projections **138** disposed on both sides of the groove portion **116**B, a contact portion **136**B formed by a projection **140** located on one side (counterclockwise side in the figure) of the contact portion **136**A, and a contact portion **136**C formed by a projection **142** located on the other side (clockwise side in the figure) of the contact portion **136**A. That is, the groove portion **116**B is provided in the contact portion **136**A.

As illustrated in FIG. **1**C, in the state in which the contact member **116** is located (supported) within the cylindrical body **108**, All angles formed by two of the straight lines passing through circumferential center portions of the contact portions **136** and the axial center F of the cylindrical body **108** (image carrier **56**) are 120 degrees (angle N in FIG. **1**C).

Further, as illustrated in FIGS. **1**B and **1**C, in a state in which the contact member **116** is not disposed within the cylindrical body **108**, a separate distance (distance K in the figures) of the separate portion **116**A is longer than when the contact member **116** is disposed within the cylindrical body **108**.

In this structure, when the contact member **116** is disposed within the cylindrical body **108**, it is held and bent by deforming the groove portion **116**B to shorten the separate distance of the separate portion **116**A. In this state, the contact member **116** is inserted into the cylindrical body **108**, and the holding force is removed. Thus, the contact portions **136**A, **136**B, and **136**C of the contact member **116** are brought into contact with the inner peripheral surface **108**A of the cylindrical body **108**, and the contact member **116** is disposed and supported within the cylindrical body **108**.

That is, the contact member **116** is disposed in a bent state within the cylindrical body **108**.

Others

As illustrated in FIG. **2**, a motor **122** is disposed at one side of the image carrier **56** in the apparatus depth direction. The motor **122** serves as an example of a driving source that generates rotational force to be transmitted to the image carrier **56** (transmission member **110**).

A body **122**A of the motor **122** is attached to a platelike frame **124** disposed within the apparatus body **10**A (see FIG. **4**). Further, a motor shaft portion **122**B of the motor **122** extends on the axial center F of the cylindrical body **108**, passes through a through hole **126**A provided in a housing **126** of the image forming unit **70** (see FIG. **3**), and is inserted in the through hole **110**A of the transmission member **110**. To an outer peripheral surface of the motor shaft portion **122**B, a platelike bracket **128** is fixed such that distal ends thereof are bent and inserted in the recesses **110**B of the transmission member **110**. Thus, the transmission member **110** is assembled integrally (in a rattle-free state) with the motor

shaft portion **122**B. The transmission member **110** transmits the rotational force generated by the motor **122** to the cylindrical body **108**.

In contrast, a shaft member **130** is disposed at the other side of the image carrier **56** in the apparatus depth direction. The shaft member **130** has a columnar shaft portion **130**C that rotatably supports the image carrier **56** (support member **112**).

The shaft member **130** is made of a resin material (for example, ABS resin), and includes a pedestal portion **130**A attached to an inner side surface **126**B of the housing **126**, and a stepped portion **130**B disposed on the pedestal portion **130**A on a side of the image carrier **56** with a height difference. The shaft member **130** further includes a shaft portion **130**C extending from the stepped portion **130**B on the axial center F of the cylindrical body **108** to be inserted in the through hole **112**A of the support member **112**.

The support member **112** functions as a so-called sliding bearing for the shaft portion **130**C. A gap is provided between an inner peripheral surface of the through hole **112**A and an outer peripheral surface of the shaft portion **130**C.

In this structure, when the motor **122** is operated, the motor shaft portion **122**B rotates. Rotation of the motor shaft portion **122**B is transmitted to the cylindrical body **108** via the bracket **128** and the transmission member **110** fixed to the one side of the cylindrical body **108**. Then, the support member **112** fixed to the other side of the cylindrical body **108** rotates relative to the shaft portion **130**C, and the image carrier **56** is thereby rotated around the axial center F.

Operation of Principal Structure

Next, the operations of the image carrier **56**, the charging roller **58**, and so on will be described.

When the motor **122** is operated, the image carrier **56** rotates. When the image carrier **56** rotates, the charging roller **58** is rotated along with the rotation. To charge the unillustrated photosensitive layer of the image carrier **56**, a superimposed voltage obtained by superimposing an alternating-current voltage on a direct-current voltage is applied from the power supply to the shaft portion **58**A of the charging roller **58**.

By the alternating-current voltage (1 to 3 kHz) included in the superimposed voltage, an alternating electric field is generated between the charging roller **58** and the image carrier **56**. Thus, a periodic electrostatic attractive force (2 to 6 kHz) is generated between the image carrier **56** and the charging roller **58**.

Here, an image carrier **200** serving as a first comparative example will be described with reference to FIGS. **5**A, **5**B, **6**A, and **6**B in contrast to the image carrier **56** of the first exemplary embodiment, and an image carrier **204** serving as a second comparative example will be described with reference to FIGS. **7**A and **7**B in contrast to the image carrier **56** of the first exemplary embodiment.

First, the image carrier **200** will be described. The image carrier **200** has a structure similar to that of the image carrier **56** except that the contact member **116** is not provided.

FIGS. **5**A and **5**B exaggeratedly illustrate an example of a deformed state of a cylindrical body **108** of the image carrier **200** when a periodic electrostatic attractive force is generated between the image carrier **200** and a charging roller **58**. Since a transmission member **110** and a support member **112** are fixed to opposite ends of the cylindrical body **108** in the apparatus depth direction (see FIG. **2**), deformation of a cross section of the cylindrical body **108** is suppressed at the opposite ends in the apparatus depth direction. In contrast, in the center portion of the cylindrical body **108** in the apparatus depth direction, the cross section of the cylindrical body **108** periodically deforms in an elliptic shape, as illustrated in FIG. **5**B.

Similarly, FIGS. **6**A, **6**B, and **6**C exaggeratedly illustrate another example of a deformed state of the cylindrical body **108** of the image carrier **200** when a periodic electrostatic attractive force is generated between the image carrier **200** and the charging roller **58**. As described above, deformation of the cross section of the cylindrical body **108** is suppressed at the opposite ends of the cylindrical body **108** in the apparatus depth direction. In contrast, between the center portion and one end of the cylindrical body **108** in the apparatus depth direction, the cross section of the cylindrical body **108** is deformed in a vertical elliptic shape by the above-described periodic electrostatic attractive force, as illustrated in FIG. **6**B. Between the center portion and the other end of the cylindrical body **108** in the apparatus depth direction, the cross section of the cylindrical body **108** is deformed in a horizontal elliptic shape, as illustrated in FIG. **6**C.

Next, the image carrier **204** will be described. The image carrier **204** has a structure similar to that of the image carrier **56** except that the shape of a contact member **206** is different from that of the contact member **116**.

The contact member **206** has a structure similar to that of the contact member **116** except that contact portions **136** are formed in four areas, not in three areas, in contrast to the contact member **116**. Specifically, as illustrated in FIGS. **7**A and **7**B, each of the contact portions **136** of the contact member **206** is formed by one projection **208**. In a state in which the contact member **206** is disposed within the cylindrical body **108**, all angles formed by two adjacent straight lines of the straight lines passing through the contact portions **136** and the axial center F of the cylindrical body **108** (image carrier **204**) are 90 degrees (angle M in FIG. **7**B).

For this reason, as illustrated in FIGS. **7**A and **7**B, in the image carrier **204**, when the cross section of the cylindrical body **108** periodically deforms in a vertical elliptic shape and a horizontal elliptic shape, deformation of the cross section of the cylindrical body **108** is not suppressed.

However, unlike the image carriers **200** and **204** of the first and second comparative examples, the image carrier **56** of the first exemplary embodiment has the contact member **116**, and the contact portions **136** of the contact member **116** are provided in three areas on the outer peripheral surface **118**, as illustrated in FIG. **1**C. Further, in the state in which the contact member **116** is disposed within the cylindrical body **108**, all angles formed by two of the straight lines passing through the contact portions **136** and the axial center F of the cylindrical body **108** (image carrier **56**) are 120 degrees (angle N in FIG. **1**C).

For this reason, even when the cross section of the cylindrical body **108** is going to deform in an elliptic shape, deformation of the cross section of the cylindrical body **108** (image carrier **56**) in the elliptic shape may be suppressed by the contact portions **136** in three areas. In other words, periodic deformation of the cross section of the cylindrical body **108** may be suppressed when the surface of the image carrier **56** is charged by the charging roller **58**.

Since periodic deformation of the cross section of the cylindrical body **108** is suppressed, sound produced by the periodic deformation may be reduced.

Since the contact portions **136** are provided in three areas on the outer peripheral surface **118**, they are in contact with the inner peripheral surface **108**A of the cylindrical body **108** even if there are manufacturing variations in the heights of the projections **138**, **140**, and **142**.

The separate portion **116**A and the groove portion **116**B are provided in the contact member **116**, and the contact member **116** is disposed within the cylindrical body **108** while being bent with the groove portion **116**B being deformed. That is, the contact member **116**, in which the contact portion **136**B is provided on one side of the groove portion **116**B and the contact portion **136**C is provided on the other side of the groove portion **116**B, is disposed in a bent state within the cylindrical body **108**. Thus, the contact portions **136** in three areas may be in contact with the inner peripheral surface **108**A of the cylindrical body **108** in a better-balanced manner than when the contact portions are provided in two areas on one side of the groove portion **116**B.

Second Exemplary Embodiment

Next, a contact member, an image carrier, and an image forming apparatus according to a second exemplary embodiment of the present invention will be described with reference to FIG. **8**A. The same components as those adopted in the first exemplary embodiment are denoted by the same reference numerals, and descriptions thereof are skipped. The following description will be given with a focus on differences from the first exemplary embodiment.

A groove portion **170**B of a contact member **170** according to the second exemplary embodiment is provided in an inner peripheral surface **172** of the contact member **170** on a side of the axial center F of a cylindrical body **108** opposite from a separate portion **116**A. A contact portion **136**D is formed by one projection **174** disposed on an opposite side from the groove portion **170**B, when viewed from the apparatus depth direction. The operation is similar to that of the first exemplary embodiment.

Third Exemplary Embodiment

Next, a contact member, an image carrier, and an image forming apparatus according to a third exemplary embodiment of the present invention will be described with reference to FIG. **8**B. The same components as those adopted in the second exemplary embodiment are denoted by the same reference numerals, and descriptions thereof are skipped. The following description will be given with a focus on differences from the second exemplary embodiment.

Groove portions **180**B of a contact member **180** according to the third exemplary embodiment are provided in two areas on an inner peripheral surface **182** of the contact member **180**. Specifically, the groove portions **180**B are provided in a portion of the inner peripheral surface **182** between a projection **140** and a projection **174** and a portion of the inner peripheral surface **182** between a projection **142** and the projection **174**. The operation is similar to that of the second exemplary embodiment.

Fourth Exemplary Embodiment

Next, a contact member, an image carrier, and an image forming apparatus according to a fourth exemplary embodiment of the present invention will be described with reference to FIG. **8**C. The same components as those adopted in the second exemplary embodiment are denoted by the same reference numerals, and descriptions thereof are skipped. The following description will be given with a focus on differences from the second exemplary embodiment.

A contact member **190** according to the fourth exemplary embodiment is not shaped like a circular cylinder, but is shaped like a triangular cylinder. The operation is similar to that of the second exemplary embodiment

Fifth Exemplary Embodiment

Next, a contact member, an image carrier, and an image forming apparatus according to a fifth exemplary embodiment of the present invention will be described with reference to FIGS. **9**A and **9**C to **11**A, **11**B, and **11**C. The same components as those adopted in the first exemplary embodiment are denoted by the same reference numerals, and descriptions thereof are skipped. The following description will be given with a focus on differences from the first exemplary embodiment.

Structure

As illustrated in FIGS. **9**A and **9**B, a contact member **220** according to the fifth exemplary embodiment is partly separated in the circumferential direction to form a separate portion **220**A. In a state in which the contact member **220** is disposed within a cylindrical body **108**, a groove portion **220**B extending in the apparatus depth direction (axial direction) is provided on an outer peripheral surface **222** of the contact member **220** on a side of the axial center F of the cylindrical body **108** opposite from the separate portion **220**A.

The outer peripheral surface **222** of the contact member **220** also has a contact portion **236**A composed of a pair of projections **238** disposed on opposite sides of the groove portion **220**B and provided in contact with an inner peripheral surface **108**A of the cylindrical body **108**, when viewed from the apparatus depth direction. The outer peripheral surface **222** also has a contact portion **236**B formed by a projection **240** provided on one side (counterclockwise side in the figures) of the contact portion **236**A, and a contact portion **236**C formed by a projection **242** provided on the other side (clockwise side in the figures) of the contact portion **236**A.

The contact portions **236**B and **236**C are arc-shaped or substantially arc-shaped to have a radius less than a radius (inner radius) of the inner peripheral surface **108**A of the cylindrical body **108**, when viewed from the apparatus depth direction. In the fifth exemplary embodiment, for example, the radius (radius R**1** in the figure) of the inner peripheral surface **108**A of the cylindrical body **108** is 14.25 mm, and the radius (radius R**2** in the figure) of the contact portions **236**B and **236**C is 10 mm.

Evaluation

Next, a description will be given of results of evaluation of the contact positions where the contact portions **236** (**236**A, **236**B, and **236**C) and the inner peripheral surface **108**A of the cylindrical body **108** are in contact with each other when the contact member **220** of the fifth exemplary embodiment is disposed within the cylindrical body **108** and the ambient temperature is changed to a low temperature (10° C.), a room temperature (20° C.), and a high temperature (50° C.). The evaluation is performed using simulation in a finite element method.

In the evaluation, aluminum is used as the material of the cylindrical body **108**, and ABS resin is used as the material of the contact member **220**. As described above, the radius of the inner peripheral surface **108**A of the cylindrical body **108** is 14.25 mm, and the radius of the contact portions **236** is 10 mm.

In a graph of FIG. **10**, the vertical axis shows the angle R (angle L) in FIG. **9**A, and the horizontal axis shows the ambient temperature near the cylindrical body **108** in which the contact member **220** is disposed. As illustrated in FIG. **9**A, the angle R (angle L) is formed by a line segment Y extending

from the axial center F and passing through the center of the groove portion **220**B and a line segment X (line segment P) extending from the axial center F and passing through the contact position between the contact portion **236**B (contact portion **236**C) and the inner peripheral surface **108**A.

At the room temperature, the angle R (angle L) is 120 degrees. When the ambient temperature is increased or decreased, the shape of the cylindrical body **108** and the shape of the contact member **220** change relative to each other because of the difference between the linear expansion coefficient of the cylindrical body **108** and the linear expansion coefficient of the contact member **220**. Thus, the contact position between the contact portion **236**B (contact portion **236**C) and the inner peripheral surface **108**A changes. However, since the contact portions **236**B and **236**C are arc-shaped or substantially arc-shaped, the change of the angle R (angle L) is smaller than in a comparative example (to be described below) even when the ambient temperature changes to a low temperature or a high temperature, as shown in the graph of FIG. **10**.

In the comparative example, as illustrated in FIG. **11**A, a contact portion and an inner peripheral surface **108**A are in surface contact with each other at the room temperature. However, as illustrated in FIGS. **11**B and **11**C, at a low temperature or a high temperature, the contact position therebetween is moved owing to the relative change of the shapes of a cylindrical body **108** and a contact member.

Operation and Conclusion

The contact portions **236**B and **236**C are arc-shaped or substantially arc-shaped, when viewed from the apparatus depth direction. For this reason, the contact positions between the contact portions **236** and the inner peripheral surface **108**A may be restricted from varying owing to the change in ambient temperature more than when the contact portions and the inner peripheral surface **108**A are in surface contact with each other.

The contact portions **236**B and **236**C are arc-shaped or substantially arc-shaped, when viewed from the apparatus depth direction. For this reason, similar to the operation in response to the change in ambient temperature, the contact positions between the contact portions **236** and the inner peripheral surface **108**A may be restricted from varying owing to variation in the shape of the cylindrical body **108** or the shape of the contact member **220** relative to the designed value.

When the variation in contact positions between the contact portions **236** and the inner peripheral surface **108**A is suppressed, variation in the natural frequency of the image carrier **56** may be suppressed.

In the image carrier **56**, uneven charging may be suppressed because the variation in the natural frequency is suppressed.

Sixth Exemplary Embodiment

Next, a contact member, an image carrier, and an image forming apparatus according to a sixth exemplary embodiment of the present invention will be described with reference to FIG. **12**. The same components as those adopted in the fifth exemplary embodiment are denoted by the same reference numerals, and descriptions thereof are skipped. The following description will be given with a focus on differences from the fifth exemplary embodiment.

As illustrated in FIG. **12**, unlike the fifth exemplary embodiment, a separate portion **250**A of a contact member **250** according to the sixth exemplary embodiment is disposed to extend across a projection **238**. Further, unlike the fifth exemplary embodiment, a groove portion **250**B of the contact member **250** of the sixth exemplary embodiment is disposed on a side of the axial center F opposite from the separate portion **250**A.

For this reason, when the contact member **250** is disposed within the cylindrical body **108** while deforming the groove portion **250**B and bending the contact member **250** in directions of arrows S, a contact portion **236**B (**236**C) presses an inner peripheral surface **108**A in directions of arrows T in the figure. Hence, pressing force of the contact portion **236**B (**236**C) for pressing the inner peripheral surface **108**A may be more effectively transmitted to the cylindrical body **108** than when the inner peripheral surface **108**A is pressed in a tangential direction of the contact portion **236**B (**236**C) at the contact position between the contact portion **236**B (**236**C) and the inner peripheral surface **108**A.

The foregoing description of the exemplary embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, thereby enabling others skilled in the art to understand the invention for various embodiments and with the various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalents.

For example, in the above embodiments, all angles formed by two of the straight lines passing through the contact portions **136** and the axial center F of the cylindrical body **108** (image carrier **56**) are 120 degrees in the state in which the contact member **116**, **170**, **180**, or **190** is disposed within the cylindrical body **108**. However, the angles do not always need to be 120 degrees, and it is only necessary that all the angles formed by the two straight lines should be more than 90 or about 90 degrees.

Although not particularly described in conjunction with the above exemplary embodiments, when plural projections are provided in the contact portions, it is only necessary that all the angles (angles J in FIG. **1**C) formed by two of the straight lines passing through the projections formed at the adjacent contact portions and the axial center F of the cylindrical body **108** should be 90 or more degrees.

Although not particularly described in conjunction with the above exemplary embodiments, the groove portions **116**B, **170**B, and **180**B provided in the contact portions **116**, **170**, **180**, and **190** may be, for example, rectangular, V-shaped, or U-shaped.

While the projections extend in the apparatus depth direction on the contact member in the above exemplary embodiments, they may be partly separated.

While the groove portions **116**B, **170**B, and **180**B are provided in the contact members **116**, **170**, **180**, and **190** in the above exemplary embodiments, they are not always need to be provided.

While the contact portions extend in the apparatus depth direction in the above exemplary embodiments, they may be helically formed on the outer peripheral surface of the contact member.

While the contact member is formed of ABS resin in the above exemplary embodiments, it may be formed of other materials (for example, a resin material or a metal material).

While the contact portions **236**B and **236**C are arc-shaped or substantially arc-shaped in the fifth and sixth exemplary

embodiments, it is only necessary that at least one contact portion **236** should be arc-shaped or substantially arc-shaped.

While the contact portions **236**B and **236**C are arc-shaped or substantially arc-shaped in the fifth and sixth exemplary embodiments, all of the contact portions **236** may be arc-shaped or substantially arc-shaped by shifting the groove portion or the separate portion.

While the contact portions **236**B and **236**C are arc-shaped or substantially arc-shaped by making the entire projections **240** and **242** arc-shaped in the fifth and sixth exemplary embodiments, it is only necessary that the portions in contact with the inner peripheral surface **108**A of the cylindrical body **108** should be arc-shaped or substantially arc-shaped. As illustrated in FIGS. **13**A and **13**B, portions other than the portions in contact with the inner peripheral surface **108**A of the cylindrical body **108** do not always need to be arc-shaped.

What is claimed is:

1. A contact member fitted in a cylindrical body of an image carrier, and supported by the cylindrical body, the contact member comprising:

a plurality of projections extending from an outer peripheral surface of the contact member, the plurality of projections comprising a first projection, a second projection, and a pair of projections that are different from the first and second projections;

a plurality of contact portions, each of the plurality of contact portions being provided on the outer peripheral surface of each of the plurality of projections, in contact with an inner peripheral surface of the cylindrical body, and provided in three areas in a circumferential direction of the cylindrical body, each of the three areas corresponding to a respective outer peripheral surface of the first projection, the second projection and the pair of projections; and

a groove portion extending in the axial direction and being disposed between the pair of projections, and being disposed on a side of the axial center opposite from a gap portion of the contact member, the contact member being partly separated in a circumferential direction to form the gap portion, and

angles formed by two straight lines passing through two of the contact portions, the contact portions being respectively provided on the plurality of projections, and an axial center of the cylindrical body being about 120 degrees when the contact member is supported within the cylindrical body, and when viewed from an axial direction of the cylindrical body.

2. The contact member according to claim **1**,

wherein the groove portion is provided in one of the contact portions, and

wherein the contact member is disposed within the cylindrical body while being bent with a reduced separate distance of the gap portion.

3. The contact member according to claim **1**, wherein at least one of the contact portions is arc-shaped to have a radius less than a radius of the inner peripheral surface of the cylindrical body, when viewed from the axial direction.

4. The contact member according to claim **2**, wherein at least one of the contact portions is arc-shaped to have a radius less than a radius of the inner peripheral surface of the cylindrical body, when viewed from the axial direction.

5. An image carrier comprising:

a cylindrical body that bears an image on a surface thereof; and

the contact member according to claim **1**, the contact member being disposed within the cylindrical body.

6. An image forming apparatus comprising:

the image carrier according to claim **5**;

a charging device that charges a surface of the image carrier;

an exposure device that forms an electrostatic latent image by exposing the charged surface of the image carrier; and

a developing device that develops the electrostatic latent image formed on the surface of the image carrier into a toner image.

7. The contact member according to claim **1**, wherein the contact member is cylindrical.

8. The contact member according to claim **1**, wherein the contact member is C-shaped.

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